International Journal of Environment, Agriculture and Biotechnology, 5(4)
Jul-Aug, 2020 | Available: https://ijeab.com/

Effects of Climate Change Adaptation Strategies on Technical Efficiency of Poultry Production in Benue State, Nigeria

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***Abstract*— *This study determined the effects of climate change adaptation strategies on technical efficiency of poultry production in Benue State, Nigeria. The population of the study consist of all poultry farmers in Benue State. A sample size of 198 was selected using multistage sampling technique. Data for the study were collected from primary source using a structured questionnaire. Data were analyzed using descriptive statistics such as frequencies distribution, percentages and mean as well as inferential statistics such as Stochastic frontier production function. Farmers' perceived intensity of climate change as very high temperature, excessive rainfall, drought, irregular relative humidity, excessive sunshine and long period of harmattan with almost all variables exceeding the cut-off mean of 2.0. Majority of the respondents used adaptation strategies to cope with climate change. The result of the stochastic frontier analysis showing the climate change adaptation strategies influencing inefficiency of poultry output showed that, raising of broods and sell, tree planting around poultry house, more water served were found to reduce farmers' economic inefficiency of poultry output at 10% level of significance. The study hence, revealed that climate change adaptation strategies had significant relationship with economic inefficiency of poultry production in the study area. Therefore, the study recommended the need to improve on farmers' access to information on climate change and appropriate adaptation strategies as well as providing credit facilities to help improve farmers' capacity to adapt to climate change.*

***Keywords*— Climate change, Adaptation strategies, Technical efficiency and Poultry production.**

I. INTRODUCTION

Agriculture and climate are mutually dependent. Agriculture both contributes to climate change and is affected by climate change. Agricultural activities including indirect effects through deforestation and other forms of land conversion account for about one third of total global warming potential from greenhouse gas (GHG) emissions today (IPCC, 2001a). As a result of large-scale activities, inadequate management and improper implementation, agriculture is a significant contributor to land and water degradation, and in particular a major emitter of greenhouse gases (Intergovernmental Panel on Climate Change IPCC, 2007a).The issue of climate change has become more threatening not only to the sustainable development of socio-economic and agricultural activities of any nation but to the totality of human existence (Adejuwon 2004).

Climate change, refers to a change in the state of the climate that can be identified (e.g using statistical test) by changes in the variability of its properties, and that persist for an extended period, typically decades or longer (IPCC,2007b). Climate change causes variations in weather conditions which in turn has impact on agricultural productivity. Increase in temperature causes excessive vaporization leading to poor agricultural productivity.

One of the most urgent problems of the second millennium is the changing climate of the universe. Unfortunately, a lot of countries including Nigeria are already living with the results of this global problem. Climate change, which is largely a result of burning fossil fuels, is already affecting the Earth's temperature, precipitation, and hydrological cycles. Continued changes in the frequency and intensity of precipitation, heat waves, and other extreme events have

impact on agricultural production. Incidences of food crisis arises from a combination of factors, reduced productivity arising from lower yield is suspected to be exacerbated by climate change and related events (Nnaji, 2001; Onyenechere and Igbozurike, 2008).Climate change is a serious environmental threat to farmers and it worsens poverty because of its impact on agricultural productivity. Almost all sectors of agriculture depends on whether and climate whose variability have meant that rural farmers who implement their regular annual farm business plans, encounter total failure due to climate change effects. (Ozor, Madukwe, Enete, Amaechina, Onokala, Eboh, Ujah and Garforth, (2010). However, livestock production is likely to be adversely affected by climate change (Thornton, 2010). Thus, having a resultant effect on poultry production.

Poultry production is the process of raising domesticated birds for the purpose of producing meat and eggs for food. Poultry are birds that include fowl, turkey, duck, goose, ostrich, guinea fowl, etc which render not only economic services but contribute significantly to human food as a primary supplier of meat, egg, raw materials to industries (feathers, waste products), good source of animal protein, source of income and employment to people compared to other domestic animals (Demeke, 2004).The effects of climate change on poultry production have called for the need to adopt adaptation strategies to cope with its harmful effects.

Adaptation is the adjustments which moderates harm or exploit beneficial opportunities in response to actual or expected climate stimuli or their effects (IPCC, 2007b). Livestock genetic diversity and climate change adaptation, reveals that adaptation strategies address not only the tolerance of livestock to heat, but also their ability to survive, grow and reproduce in conditions of poor nutrition, parasites and diseases(Hoffmann, 2008). Efficiency in itself is concerned with relative performance of the processes used in transforming a set of inputs into output. The concept of efficiency has been interpreted in many forms or ways. These are technical (or physical) and allocative (or price) efficiency. Technical efficiency is the ratio of total output to total input. Chavanapoonphol *et al.* (2005) described technical efficiency of an individual farmer as the ratio of observed output to its corresponding stochastic frontier output, given the levels of the inputs used by the farmer.

Though a few studies have been conducted to assess the impact of climate change on poultry production in some states in Nigeria, there is a dearth of literature on this impact in Benue state, Nigeria. The knowledge of farmers on effects of climate change adaptation strategies will enable farmers to overcome the threats climate change poses on agricultural productivity.To address this gap, this study was designed to determine the effects of climate change adaptation strategies on technical efficiency of poultry production in Benue state, Nigeria.

The specific objectives are to:

1. assess the perception of poultry farmers on intensity of climate change;
2. identify adaptation strategies of poultry farmers to climate change in the study area;
3. determine the effect of climate change adaptation strategies on technical efficiency of poultry production.

II. METHODOLOGY

The study area for this research is Benue state. Benue State is one of the 36 states in Nigeria. The State derives its name from River Benue and lies in the middle belt region of Nigeria. Its geographical coordinates are longitude 7º 47' 0"and 10º 0' 0"East and Latitude 6º 25' 0" and 8º 08' 0" North (NPC 2006). Benue State has the total area of about 30955 km^2 and is divided into 23 Local Government Areas with the Headquarter in Makurdi.

A multistage sampling technique was used to select a sample size of 198 respondent for the study. In the first stage population of the study was stratified into two agricultural zones based on the existing zones in Benue state. The second stage involved a purposive selection of two local government area from each agricultural zones due to high level of poultry production in these area. Thirdly, three communities each were randomly selected from each local government area making a total of twelve communities. Fourthly, a sampling frame was developed for each of communities using a proportion of 30% (0.3) across board. A total sample size of 198 respondent was selected (table 1). But only190 copies of the questionnaires were returned from respondents and analyzed for the study.

The instrument of data collection used was a set of structured questionnaire that covered all the information to analyze the research objectives. The type of reliability test that was used is the test retest method. This was carried out among 20 respondents. Pearson product moment correlation was use to obtain a correlation coefficient (r)of 0.99, which implies that the instrument was reliable.

Model specification

Descriptive statistics was used to analyze objective I and II whileStochastic Frontier Production Function was used to analyze objective III

Stochastic Frontier Production Function

Stochastic frontier production function was used to estimate the Maximum Likelihood Estimates of parameters in Cobb-Douglas stochastic production function for the effects of climate change adaptation strategies on the technical efficiency of poultry production.

The model is specified as:

$lnY = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + \beta_6 lnX_6 + \beta_7 lnX_7 + \beta_8 lnX_8 + \beta_9 lnX_9 + (v_i - u_i)$

$v_i \sim N(0,\sigma^2 v)$

Where:

β = parameters estimates. Σ is the sign of summation.

Y = the value of poultry output in kilograms;

X1=the total labour used in poultry production in man days;

X2=the total farm size (poultry house) used for poultry production in metres;

X3= the total cost of feed used for poultry production in naira;

X_4= the total capital used for poultry production in naira;

X5= the total cost of drugs and vaccine used for poultry production in naira;

X_6= total cost of litter used for poultry production in naira;

X_7=total cost of equipment used for poultry production in naira;

X_8= total cost of stock (chicks) in naira;

Vi= are random variables which are assumed to be independent of *Ui*, identical and normally

distributed with zero mean and constant variance.

Ui= which are non-negative random variables which are assumed to account for technical

inefficiency in production and are often assumed to be independent of *Vi* such that *U* is

the non-negative truncated (at zero) *U* of half normal distribution with |N (0, σ2v)|.

The inefficiency of production, *Ui* is modeled in terms of the climate change adaptation strategies that are assumed to affect the efficiency of poultry production by poultry farmers.

The Technical Inefficiency Effects Model:

The technical inefficiency effect, μ_i is defined as:

$\mu i = \delta_0 + \delta_1 I_1 + \delta_2 I_2 + \delta_3 I_3 + \delta_4 I_4 + \delta_5 I_5 + \delta_6 I_6$

μ_i= inefficiency effect,

I_1 = Keeping of resistant breeds

I_2 = Prompt and extra vaccination of birds

I_3 = Raising of brood and sell

I_4 = Tree planting around poultry house

I_5 = more space per bird

I_6 = more water served

I_7 = Better hygiene

$\delta_0$andδ_i = coefficients (unknown parameters to be estimated along with the variance parametersδ^2 and γ. The varience of the random errors, δ_v^2 and that ofthe technical inefficiency effectsδ_μ^2 and the overall variance of the model are related;

δ^2=δ_v^2 + δ_μ^2.The δ^2indicates the goodness of fit and the correction of the distributional form assumed for the composite error term.

The ratio γ=δ_u^2 / δ_v^2 measures the total variation of output from the frontier which can be attributed to technical inefficiency. The estimates of the parameters of the stochastic frontier production function and the inefficiency model will be obtained simultaneously using the program frontier version 4.1

The technical efficiency is defined in terms of the ratio of observed output (Y_i) to the corresponding frontier output (Y_i) conditioned on the level of input used by the farmers. Hence the technical efficiency (TE_i) of the poultry farmers will be expressed as:

$TE_i = y_i / y_i^*$ =f (X_i,B) exp (V_i-μ_i)/f(Xi;β) exp V=exp (-μi)

Where

Y_i = Observed output

Y_i^* = Frontier output

TE_i = Ranges between 1 and 0

III. RESULTS AND DISCUSSION

Perception of Poultry Farmers on Intensity of Climate Change

Table 1 showed the distribution of the average scores of respondents on perception of poultry farmers on intensity of climate change in the study area. Majority of the farmers in the study area perceived intensity of climate change as very high temperature (Mean=3.3), excessive rainfall (Mean=2.2), drought (Mean=2.04), irregular relative humidity (Mean=2.1, excessive sunshine (Mean=3.0), wind effect (Mean=1.8), and long period of harmattan; with each variable exceeding the cut-off mean score of 2.0 except wind effect which had a mean of 1.8. This implies that the respondents have perceived evidence that climate has changed and therefore will be willing to adopt adaptation strategies related to climate change in other to reduce its effects on poultry production. This agrees with the findings of Chah, Odo, Asadu and Enwelu (2013) that excessive sunshine (90.0%), excessive rainfall (80.0%), short period of hamattan (75.5%) and increased incidence of drought (66.7%) were seen by respondents as evidence of climate change in Enugu state.

This corroborates with the findings of Adesiji etal (2013) that 78.4% of the respondents all agreed that temperature fluctuate and 98.8% observed increased sunshine intensity in Ondo state. This is also similar to the opinion of Gueye, (2003) who reported that climate changes in form of drought, temperature variability, too much sunshine and windstorm have negative effects on agricultural productivity especially on poultry production, corroborating with Yahaya, (2009) who stated that the unusual weather change which brings about rain in different parts of Nigeria in January is an indication of serious negative effects of climate change.

Table 1: Perception of Poultry Farmers on Intensity of Climate Change

Variables	Non applicable	Very high	Mean	Std. Deviation
High temperature	0	4	3.31*	0.77
Excessive rainfall	0	4	2.19*	0.82
Drought	0	4	2.04*	1.08
Irregular Relative Humidity	0	4	2.13*	0.92
Excessive sunshine	0	4	3.01*	0.85
Wind effect	0	4	1.78	0.94
Long harmattan	0	4	2.14*	0.94

Source: Field Survey, 2018

Climate Change Adaptation Strategies used by Poultry Farmers in the Study Area

Findings in table 2 showed that 97.4% of the respondents agreed they were aware of climate change with 85.8% of them having less than 7 years of awareness. This is to say that, majority of the poultry farmers in the study area have noticed variation in climatic elements. Hence they perceived climate change in various ways.

Majority of the respondents (75.8%) used better hygiene as climate change adaptation strategy since dirty environment can aid breeding of disease causal organisms. This implies that farmers used better hygiene to reduce the growth and spread of infection caused by fluctuations in climatic factors. More space per bird was used by 73.7% of the respondents as a coping strategy. This implies that farmers ensure there is enough space in the poultry house for birds to freely move about to enhance ventilation and prevent heat. This agrees with the findings of Alade and Ademola (2013) that giving more spacing per average bird will prevent generation of heat from birds. 72.1% of the respondents served more water as a coping strategy to climate change. This is because birds tend to drink more water when the temperature is high to conserve heat.

Prompt and extra vaccination of birds was used by 68.4% of the respondents to build the immune system of birds to resist and reduce the effect of diseases on birds. Keeping of resistant breeds was used by 63.2% of respondent as a coping strategy to withstand the effect of climate change to an

extent. About 59.5% of respondents used regular practice of routine management as a coping strategy to climate change to ensure that birds are well attended to and also to reduce the effect of climate change on birds. About 57.9% of respondents installed cooling equipment to reduce the heat in their poultry houses. Tree planting around poultry house was used by 55.8% of respondents to provide ventilation in their poultry houses and greatly reduce heat wave caused by high temperature and excessive sunshine. About 55.3% of respondents used keeping of early maturing birds as a coping strategy to climate change.

Table 2: Adaptation Strategies of Poultry Farmers to Climate Change in the Study Area (n = 190)

Variables	**Frequencies**	**Percentage**
Climate change awareness		
Yes	185	97.4
No	5	2.6
Years of climate change		
Awareness		
≤ 6	163	85.8
7 – 12	21	11.1
13 – 18	3	1.6
≥ 19	3	1.6
Adaptation strategy		
Keeping of resistant and improved breeds	120	63.2
Installing cooling equipment	110	57.9
Keeping of early maturing birds	105	55.3
Extension management services	17	8.9
Keeping birds varieties	44	23.3
Prompt and extra vaccination of birds	130	68.4
Raising of broods and sell	42	22.1
Tree planting around poultry house	106	55.8
More space per bird	140	73.7
More water served	137	72.1
Better hygiene	144	75.8
Regular practice of routine management	113	59.5
Others	43	22.6

*Multiple responses

Source: Field Survey, 2018

Maximum Likelihood Estimates of Parameters in the Stochastic Frontier Analysis for Effects of Climate Change Adaptation Strategies on Technical Efficiency of Poultry Production.

The analysis of the data for the technical efficiency estimates was achieved through the Maximum Likelihood Estimation (MLE) which involved the estimation of stochastic frontier model with inefficiency effects. The maximum likelihood

estimates of parameters in stochastic frontier function are presented in table 3 below. The elasticity parameters are contained in the upper segment of the table while the determinants of inefficiency are also contained in the lower segment of the table. The sigma square (1.23) is significant at 5% level which implied that the stochastic frontier production model was the model that best fit the data. The significance of the estimates of gamma () (0.93) at 1% showed that the inefficiency effects jointly estimated with the production frontier function were not simply random errors. This implied that climate change adaptation strategies as well as farm and farmer specific characteristics had significant influence on the efficiency of poultry production rejecting the null hypothesis that climate change adaptation strategies have no significant influence on technical efficiency of poultry production.

The γ- parameter shows the relative magnitude of the variance in output associated with

Technical efficiency. The coefficients of the variables derived from the Maximum Likelihood

Estimation (MLE) are very important for discussing results of the analysis of the data. These

Coefficients represent percentage change in the dependent variables as a result of percentage

change in the independent (or explanatory) variables. The coefficients presented in the upper segment of the table showed that, the parameter of chick was positive (0.29) and significant at 1%. This implied that a 100 percent increase in the number of chicks increased the value of revenue in poultry production by 29 percent. The coefficient of feed (0.68) was also positive and significantly related to poultry revenue value at 1%. The result meant that a 100% increase in quantity of feed increased poultry revenue value by 68 percent.

Climate change, farm and farmer specific variables influencing inefficiency of poultry production are contained in the inefficiency model of the lower section of Table 6. The following variables, raising of broods and sell, tree planting around poultry house, more water served had negative and significant relationship on economic inefficiency, while better hygiene had a positive and significant relationship with economic inefficiency. The climate change adaptation strategies, farm and farmer specific variables that had significant relationship with economic inefficiency were discussed below:

Raising of brood and sell was found to have a negative (-3.26) and significant relationship with farmers inefficiency in the study area. This implied that increase in raising of brood and sell would lead to reducing farmers' economic inefficiency in poultry production. This is expected because younger birds experience less heat stress and less effect of climate change hence reducing loss and increasing revenue in poultry production. The use of tree planting around poultry house was negative (-1.36) and significant to inefficiency. This implied that increasing the practice of tree planting around poultry house reduced inefficiency in the value of poultry output. Tree planting around poultry house provided ventilation and shade and also reduced the intensity of heat in poultry houses. It increased the value of poultry output by reducing the death rate of birds and other effects of climate change. More water served had a negative (-1.37) and significant relationship with farmers inefficiency in the study area. This implied that increase in the practice of serving more water would lead to reducing farmers' economic inefficiency in poultry production. This is because birds take in more water to conserve heat and reduce effects of heat on birds thereby increasing the value of poultry output. The use of better hygiene was found to have a positive (2.02) and significant relationship with farmers' inefficiency in the study area. This implied that increase in the use of better hygiene increased inefficiency in poultry production. This was not expected because better hygiene is supposed to reduce the spread of diseases and death rate.

Table 3: Maximum Likelihood Estimates of Parameters in the Stochastic Frontier Analysis for Effects of Climate Change Adaptation Strategies on Technical Efficiency of Poultry Production in Benue State

Independent variables	Coefficient	t-ratio
Constant	1.45	4.37
Chick	0.29	4.71***
Feed	0.68	10.35***
Labour	-0.002	-0.26

Fumigation	0.01	0.98
Water	0.0003	0.03
Miscellinous	0.06	1.31
Technical Inefficiency Model		
Constant	-6.18	-1.57
Farm size space	0.35	1.22
Keeping of resistant breeds	0.28	0.61
Prompt and extra vaccination of birds	0.71	1.12
Raising of broods and sell	-3.26	-1.75*
Tree planting around poultry house	-1.36	-1.74*
More space per bird	0.26	0.51
More water served	-1.37	-1.51*
Better hygiene	2.02	1.90*
Diagnostic statistics		
Sigma squared	1.23	2.43
Gamma	0.93	30.44
Likelihood function	-80.71	

*, *** = significant at 10% and 1% level respectively

Source: field survey, 2018

IV. CONCLUSION

The result on perception showed that majority of the farmers in the study area perceived intensity of climate change as very high temperature (Mean=3.3), excessive rainfall (Mean=2.2), drought (Mean=2.04), irregular relative humidity (Mean=2.1, excessive sunshine (Mean=3.0), wind effect (Mean=1.8), and long period of harmattan with each variable exceeding the cut-off mean score of 2.0 except wind effect which had a mean of 1.8.

The result also shows that majority (97.4%) of farmers agreed they were aware of climate change with 85.8% having 6 years of awareness. The analysis of data on climate change adaptation strategies revealed that majority of the respondents used better hygiene (75.8%), More space per bird (73.7%), More water served (72.1%), Prompt and extra vaccination of birds (68.4%), Keeping of resistant breeds (63.2%), regular practice of routine management (59.5%), installed cooling equipment (57.9%), Tree planting around poultry house (55.8%) and keeping of early maturing birds (55.3%) as climate change adaptation strategies on poultry production.

The result of the stochastic frontier analysis showing the climate change adaptation strategies influencing inefficiency of poultry output showed that, raising of broods and sell, tree planting around poultry house, more water served were found to reduce farmers' economic inefficiency of poultry output at 10% level of significance.

RECOMMENDATIONS

Based on the findings of this, the following recommendation are made:

i. There is need to improve on farmers' access to climate change information as well as to promote adaptation methods that are appropriate for specific climate change related risks.

ii. Effort should be made to provide credit facilities to help improve farmers' capacity to adapt to climate change.

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